Jun 5th, 10:30 AM - 10:50 AM

Session C1 - Stream Functions Pyramid Framework

Richard Starr
Stream Mechanics

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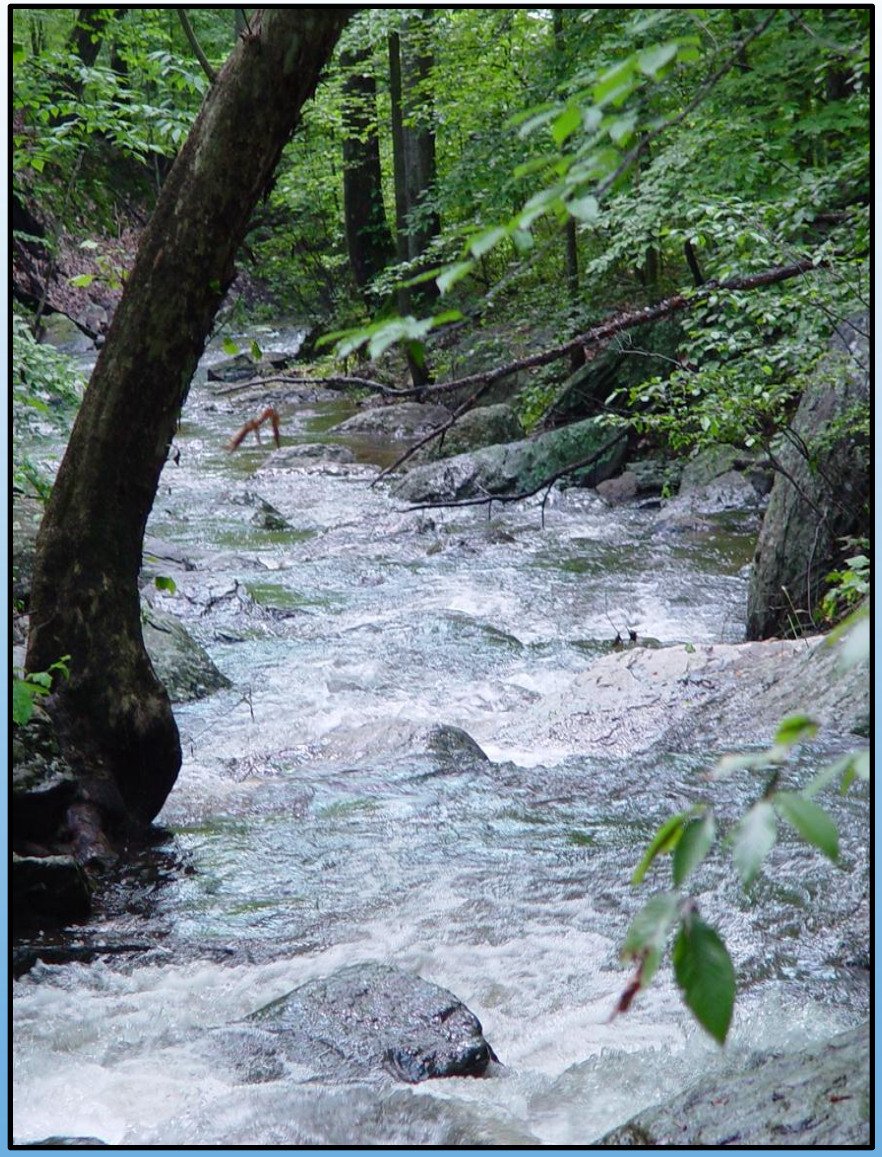
Stream Functions Pyramid Framework



Richard Starr

US Fish and Wildlife Service

Acknowledgement

- Funding and technical support was provided by the U.S. Environmental Protection Agency.
- Will Harman, Stream Mechanics.

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Why are we struggling with determining the success of stream restoration projects?

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Why are we struggling with determining the success of stream restoration projects?

Current knowledge and application of that knowledge.

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We will control the river!

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We will control the river!

No you won't!

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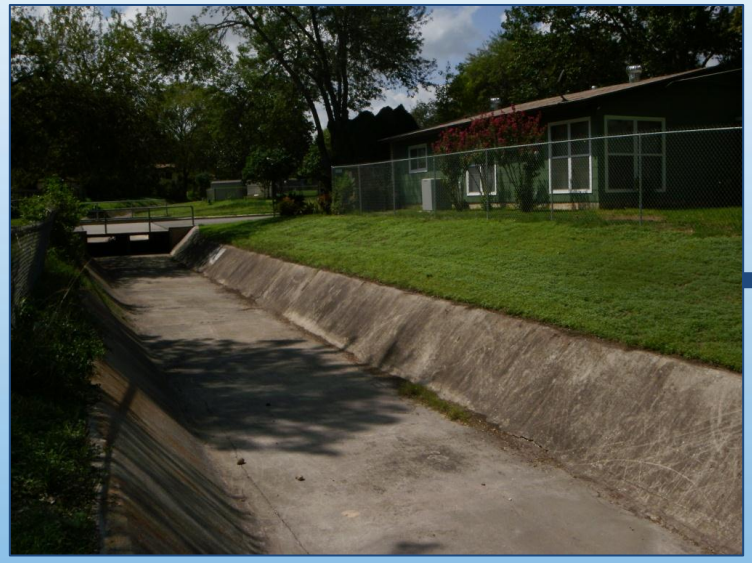
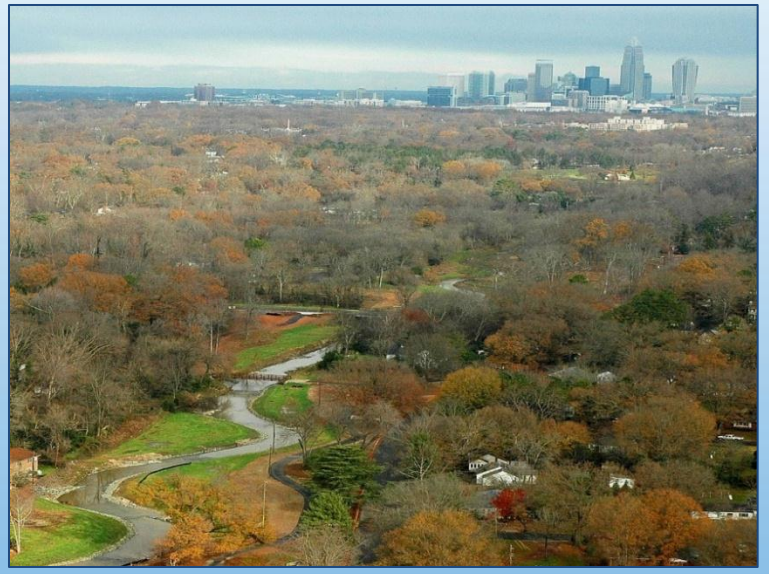
20th Century Shift



Traditional Channel Design

Transport water quickly; Bed and banks don't move



Natural Channel Design

Create a dimension, pattern, and profile that transports water and sediment.

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Source: Michael Baker Corporation

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21st Century Goal

Restoration of Dimension, Pattern, and Profile

→

Restoration of **Functions**

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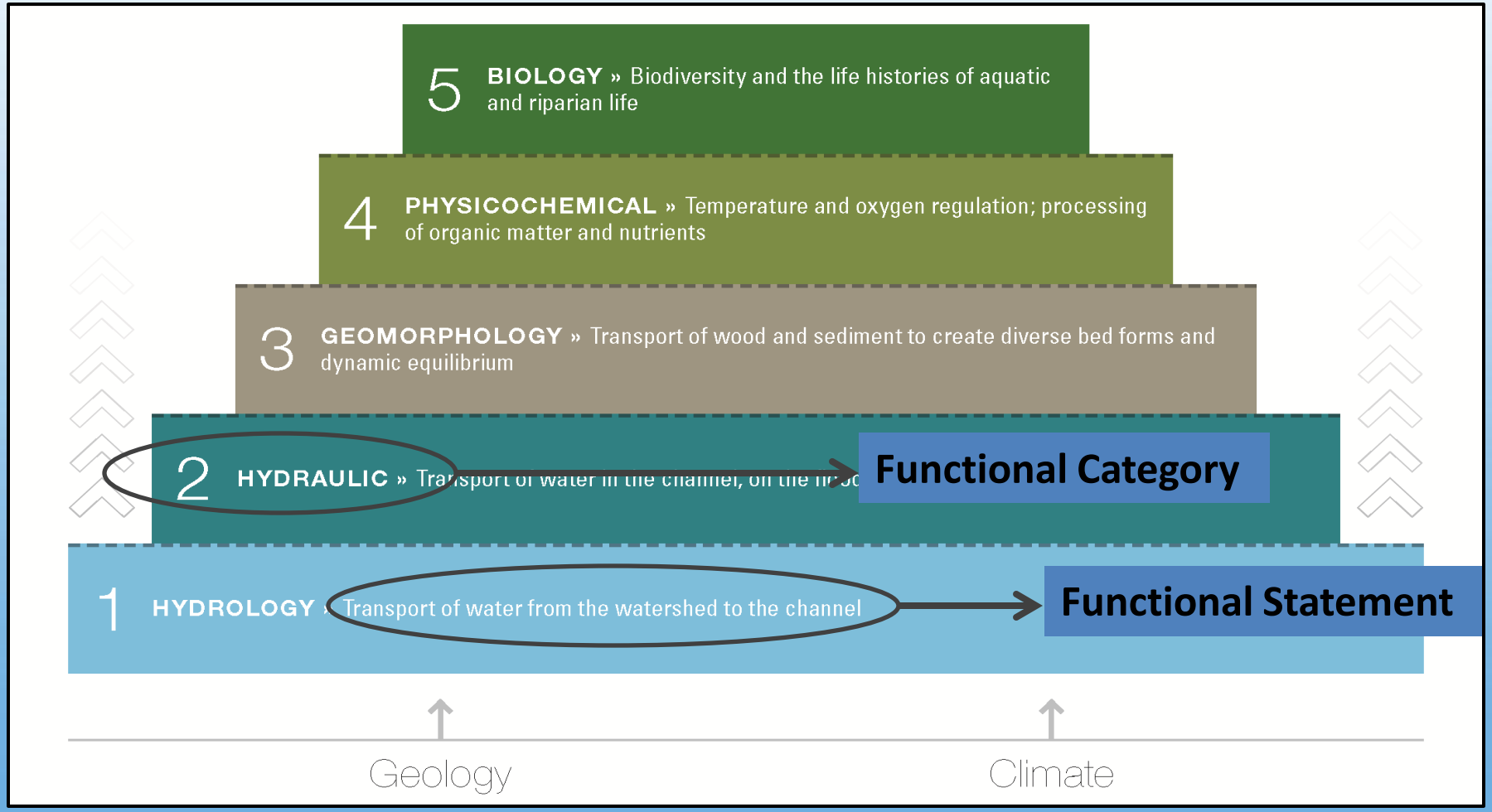
Stream Functions Pyramid

A hierarchical framework illustrating the relative relationship of stream functions and parameters that can be used to describe those functions



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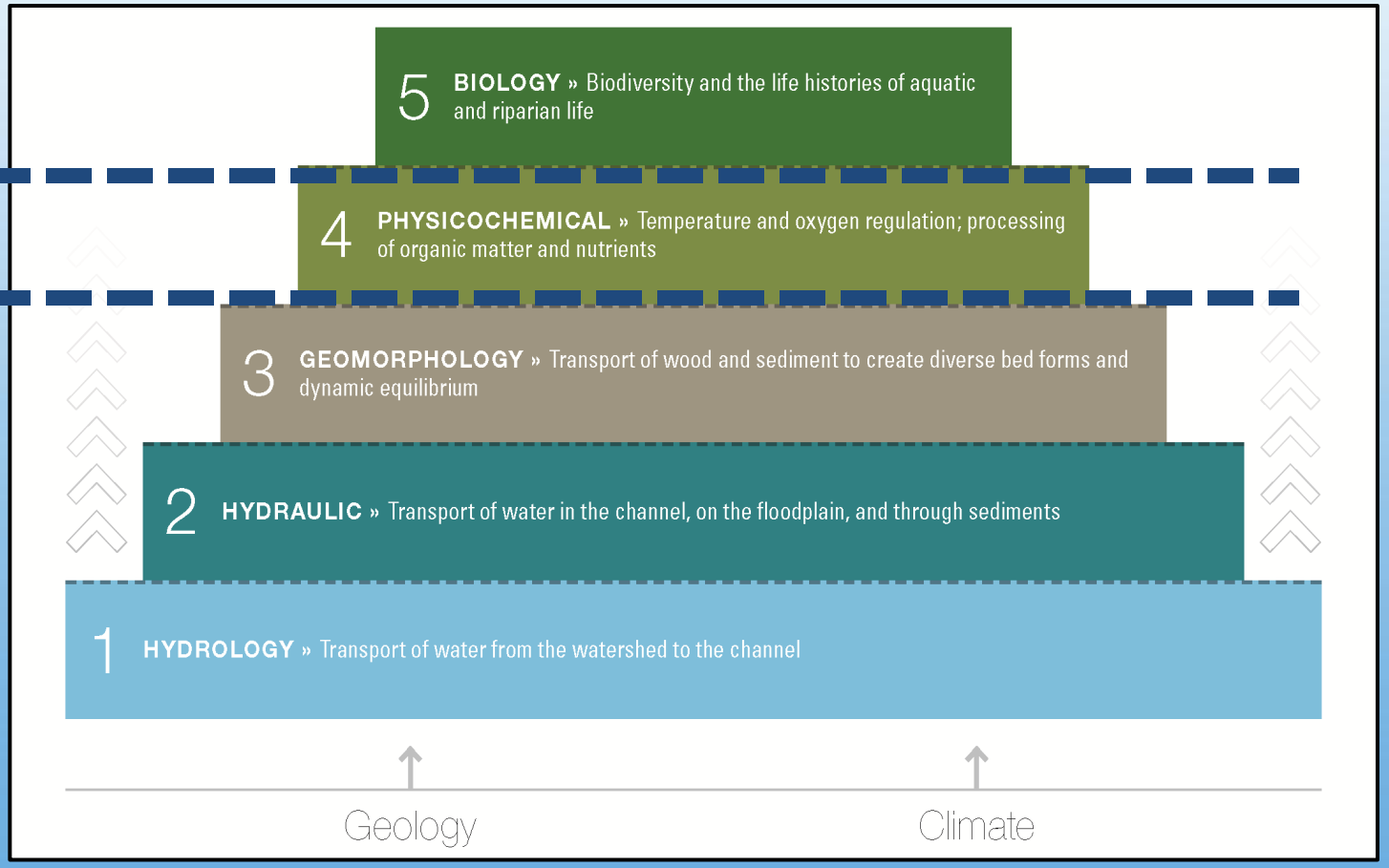
Function - The physical, chemical, and biological processes that occur in ecosystems.

Biological

Chemical

Physical



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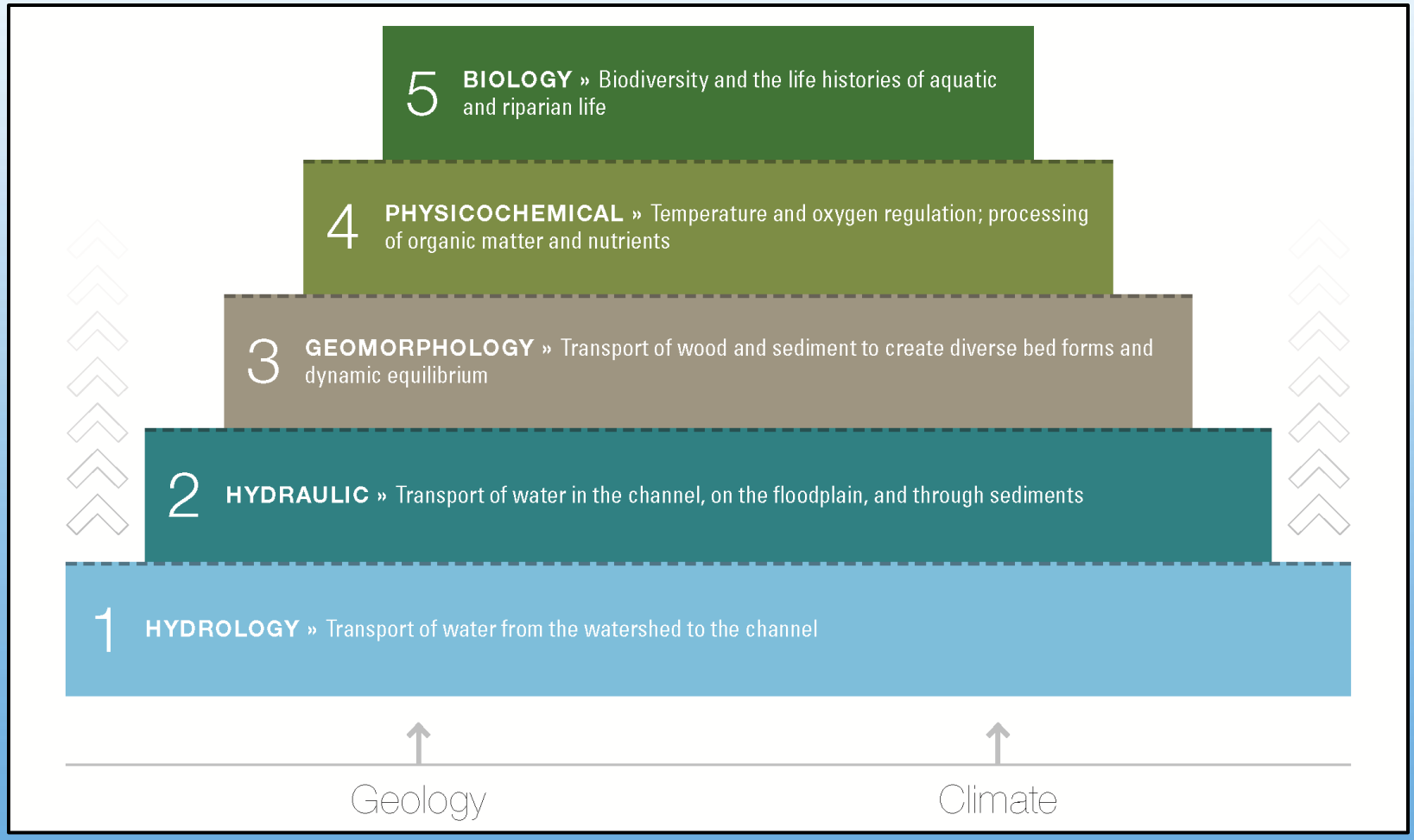
Hierarchical flow of functions influence cause and effect relationships.

Effect

Cause



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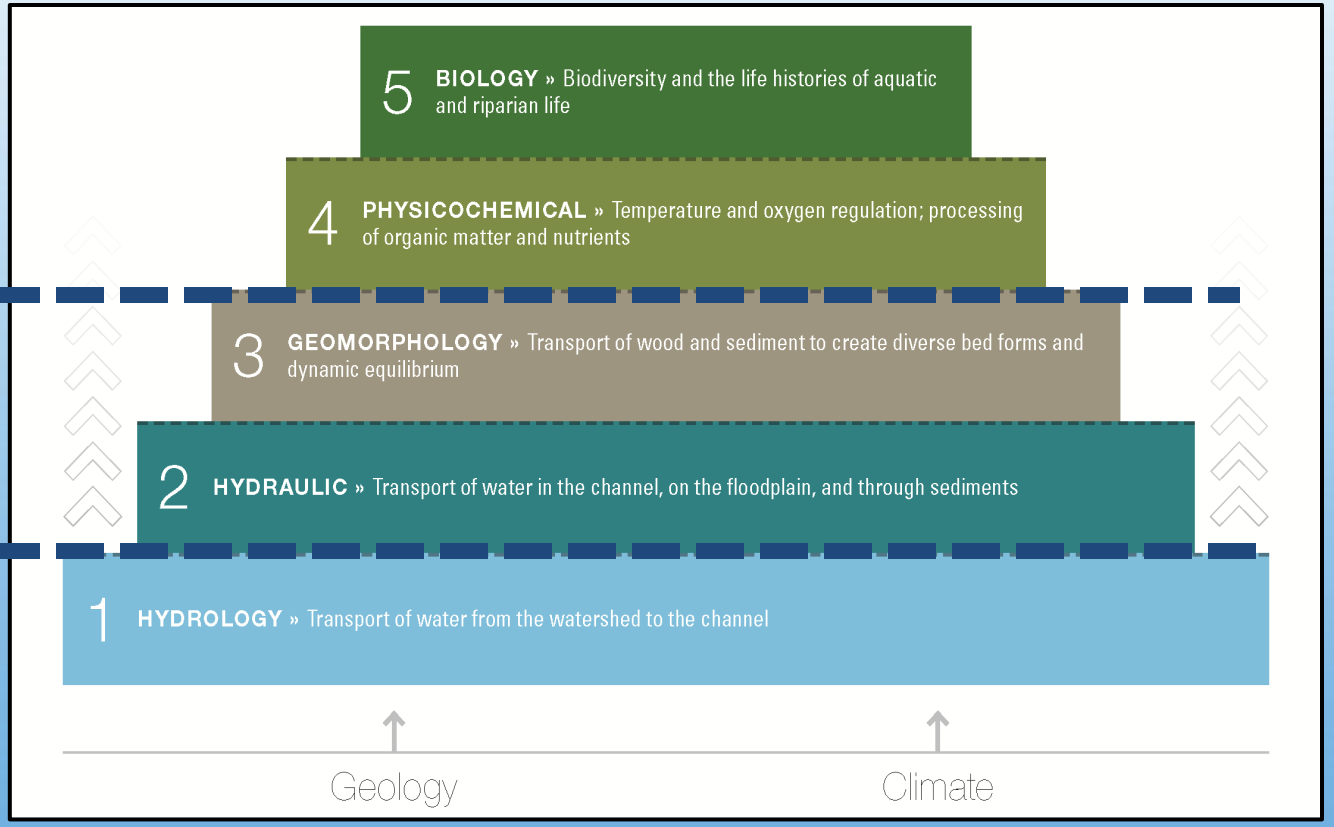
Site level potential functional lift.

Site Selection

Reach Scale Improvements

Independent Variables



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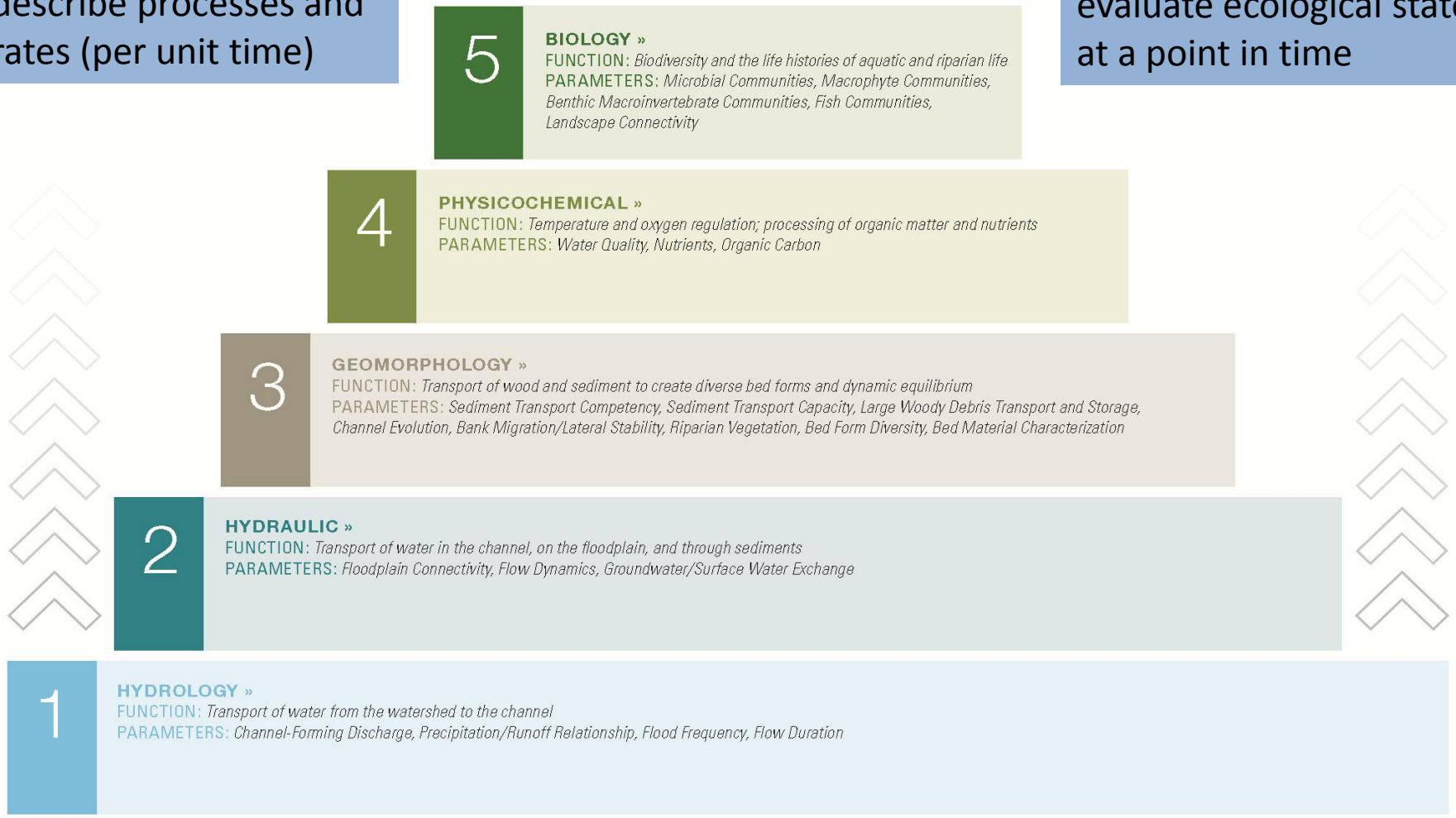
Pyramid and Parameters

Functional Attributes describe processes and rates (per unit time)

Structural measures evaluate ecological state at a point in time



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Parameters and Measurement Methods

APPENDIX A.c. Parameters and Measurement Methods

HYDROLOGY	
Parameter	**Measurement Method**
Channel-Forming Discharge	1. Regional Curves
Precipitation/Runoff Relationship	1. Rational Method 2. HEC-HMS 3. USGS Regional Regression Equations
Flood Frequency	1. Bulletin 17b
Flow Duration	1. Flow Duration Curve 2. Crest Gage 3. Monitoring Devices 4. Rapid Indicators
HYDRAULICS	
Parameter	**Measurement Method**
Floodplain Connectivity	1. Bank Height Ratio 2. Entrenchment Ratio 3. Stage Versus Discharge
Flow Dynamics	1. Stream Velocity 2. Shear Stress 3. Stream Power
Groundwater/Surface Water Exchange	1. Piezometers 2. Tracers 3. Seepage Meters

BIOLOGY	
Parameter	**Measurement Method**
Microbial Communities	1. Taxonomic Methods 2. Non-Taxonomic Methods 3. Biological Indices
Macrophyte Communities	1. Taxonomic Methods 2. Non-Taxonomic Methods 3. Biological Indices
Benthic Macroinvertebrate Communities	1. Taxonomic Methods 2. Non-Taxonomic Methods 3. Biological Indices
Fish Communities	1. Taxonomic Methods 2. Non-Taxonomic Methods 3. Biological Indices
Landscape Connectivity	1. Spatial Analysis 2. Species Tracking 3. Habitat Models

GEOMORPHOLOGY	
Parameter	**Measurement Method**
Sediment Transport Competency	1. Shear Stress Curve 2. Required Depth and Slope 3. Spreadsheets and Computer Models
Sediment Transport Capacity	1. Computer Models 2. FLOWSED and POWERSED 3. BAGS
Large Woody Debris Transport and Storage	1. Wohl, et al. (2009) 2. Large Woody Debris Index
Channel Evolution	1. Simon Channel Evolution Model 2. Rosgen Stream Type Succession Scenarios
Bank Migration/Lateral Stability	1. Aerial Photography 2. BEHI/NBS 3. Bank Pins 4. Bank Profiles 5. Cross-Sectional Surveys 6. Bank Stability and Toe Erosion Model
Riparian Vegetation	1. Buffer Width 2. Buffer Density 3. Buffer Composition 4. Buffer Growth 5. Canopy Density 6. Proper Functioning Condition (PFC)
Bed Form Diversity	1. Percent Riffle and Pool 2. Facet Slope 3. Pool-to-Pool Spacing 4. Depth Variability
Bed Material Characterization	1. Bevenger and King (1995) 2. Riffle Stability Index (RSI)
PHYSIOCHEMICAL	
Parameter	**Measurement Method**
Basic Water Chemistry	1. Temperature 2. Dissolved Oxygen 3. Conductivity 4. pH 5. Turbidity
Nutrients	1. Field test kits using reagents reactions 2. Laboratory analysis
Organic Carbon	1. Laboratory analysis

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Parameters and Measurement Methods

Quantify / Describe the Function-Based Parameter

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Parameter	Measurement Method
Floodplain Connectivity	1. Bank Height Ratio 2. Entrenchment Ratio 3. Stage/Q Relationships

GEOMORPHOLOGY	
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Sediment Transport Competency	1. Shear Stress Curve
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Performance Standards

- Based on Functional Capacity
- Divided into three categories:
  - Functioning (does support)
  - Functioning-At-Risk (can support)
  - Not Functioning (does not support)
- Similar categories as PFC, different definitions

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Performance Standards
Floodplain Connectivity Example

Measurement Method	Functioning	Functioning-At-Risk	Not Functioning
Bank Height Ratio (BHR)	1.0 to 1.2	1.3 to 1.5	> 1.5
Entrenchment Ratio (ER) for C and E Stream Types	> 2.2	2.0 to 2.2	< 2.0
Entrenchment Ratio (ER) for B and Bc Stream Types	> 1.4	1.2 to 1.4	< 1.2
Dimensionless rating curve	Project site Q/Q_{bkf} plots on the curve	Project site Q/Q_{bkf} plots above the curve	Project site Q/Q_{bkf} of 2.0 plots above 1.6 for $d/_{dbkf}$

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This is a Framework

- Users can add Function-Based Parameters, Measurement Methods, and Performance Standards to fit their region and project goals.
- Function-Based Parameter
  - Helps to describe/understand the functional statement
- Measurement Method
  - A measure of the Function-Based Parameter
- Performance Standards
  - Functional Capacity
  - Tied to Measurement Method
- Entering the Pyramid

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How can we use the pyramid?
-Application-

Function-Based Assessments

Goals and Objectives

Debit and Credit Determination

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- Set Program/Project Goals
- Relate to Functional Pyramid
- Develop data collection methodology

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- Establish the Current Functional Condition
- Channel Evolution
- Stressors
- Constraints

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- **What is the highest level of restoration that can be achieved, given the watershed conditions function-based assessment and constraints?**

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- Goals relate to solving a functional problem
- Objectives describe how the problem will be solved

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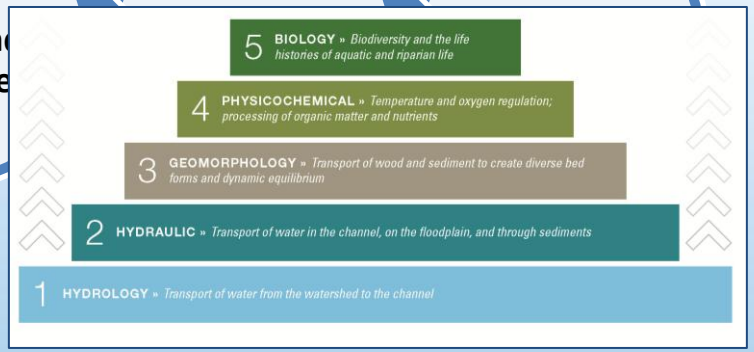
Program/ Project Goals → Function-Based Assessment → Restoration Potential → Design Goals and Objectives



- Goals relate to solving a functional problem
- Objectives describe how the problem will be solved

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- **The Solution – Based on all of the previous information.**
- **Not just to improve dimension, pattern, and profile.**

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- **Were the goals and objectives achieved?**
- **How much functional lift was achieved?**

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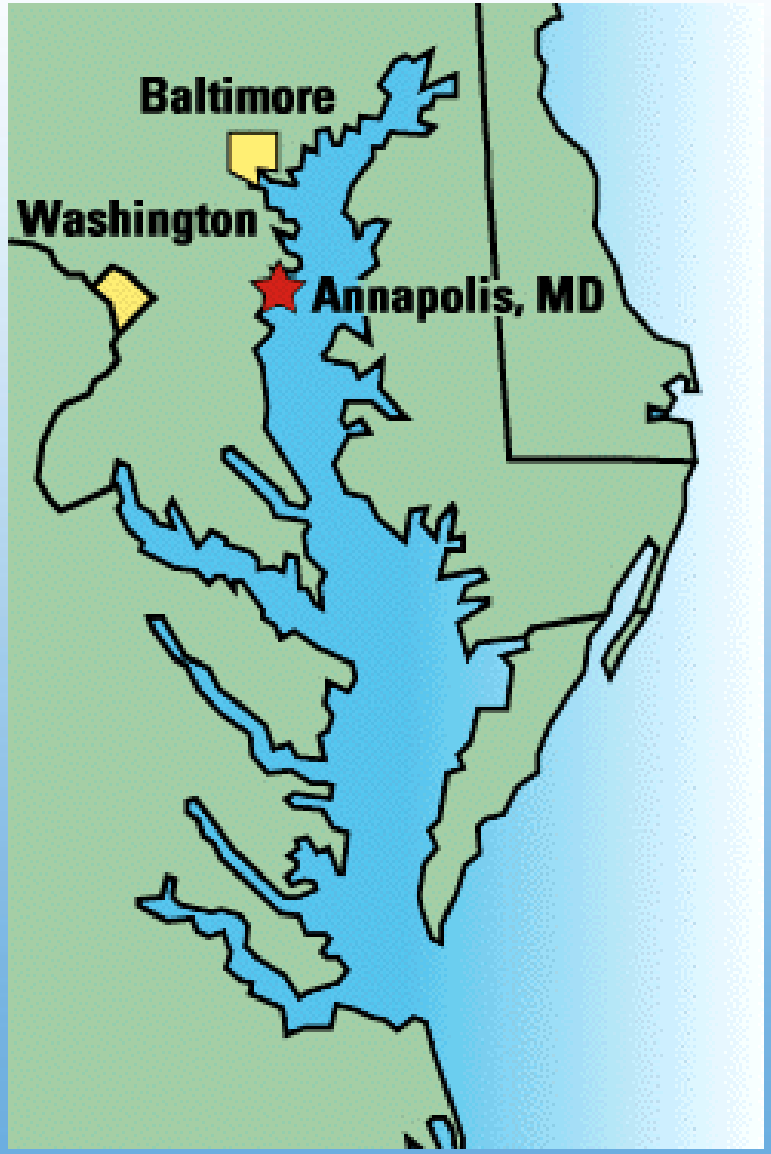

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